Journal of Applied Phycology (2006) 18: 461–467
DOI: 10.1007/s10811-006-9050-x

Photosynthesis and UV-B tolerance of the marine alga *Fucus vesiculosus* at different sea water salinities

C.A. Nygård* & N.G.A. Ekelund
Mid Sweden University, Department of Natural Sciences, SE-851 70 Sundsvall, Sweden

*Author for correspondence: e-mail: lotta.nygard@miun.se

Key words: *Fucus vesiculosus*, photosynthesis, dark respiration, UV-B, salinity, pigments, oxygen evolution

Abstract

The marine algal species in the Baltic Sea are few due to the low sea water salinity. One of the few species that can be found is *Fucus vesiculosus*. Even this species is affected by the low salinity and becomes smaller in size in the Baltic. In present work the photosynthesis of *F. vesiculosus* in the northern Baltic (Bothnian Sea) was compared to the photosynthesis of *F. vesiculosus* in the Atlantic. Oxygen evolution was measured before and after exposure to 2.3 W of UV-B (280–320 nm) radiation for 5 h, as well as after 48 h recovery in low light. The plants were kept in their own sea water salinity as well as in a changed salinity, this to examine possible correlations between salinity and photosynthesis. The results show a significant higher initial maximal photosynthesis (P_{max}) for Atlantic plants (10.3 nmol O_2 g^{-1} FW s^{-1}) compared to Baltic plants (4.0 nmol O_2 g^{-1} FW s^{-1}). The Baltic plants were found more sensitive to UV-B with a 40–50% decrease of P_{max} as well as a lower degree of recovery (60–70% compared to 75–95% for the Atlantic plants). The higher salinity (35 psu) had a positive effect on the Baltic *F. vesiculosus* with increased P_{max} as well as increased tolerance to UV-B. The lower salinity (5 psu) had a negative effect on the Atlantic plants with a decreased P_{max} as well as a lower tolerance to UV-B. Pigment content was found higher in Atlantic *F. vesiculosus*. The pigment content decreased then the Atlantic plants were transferred to 5 psu. The concentration of Chl a as well as the total content of violaxanthin, diadinoxanthin and zeaxanthin in Baltic plants increased when transferred to 35 psu. The Atlantic *F. vesiculosus* can not survive the low salinity in the northern Baltic (died within 8 weeks). It is likely that a long time acclimation or adaptation to low salinity has taken place for *F. vesiculosus* in northern Baltic. If this is an ecotypic or genotypic development it is too early to say.

Introduction

The marine brown alga *Fucus vesiculosus* L. (Phaeophyceae) is one of few marine species in the brackish water of the Baltic Sea. The low salinity gives the plants a different appearance in the Baltic with a smaller thallus and absence of the characteristic air-bladders in the northern Baltic (Waern, 1952). The northern distribution limit in the Baltic is found at 4 psu (Kalvas & Kautsky, 1998). This intertidal species grows subtidally in the Baltic, due to the absence of tides (Wallentinus, 1979). The plants extend to greater depths in the Baltic than in the Atlantic, mainly due to the lower occurrence of other macroalgae. Accordingly, the difference in depth distribution might give a different tolerance to high light and UV-radiation.

Populations of species can exist in diverse habitats either because they have diverged genotypically and/or because they have the ability to acclimatize phenotypically to the environment. Which is the case with *F. vesiculosus* is so far unknown. One way to try to distinguish these kinds from each other is to perform experiments with measurement of immediate physiological responses to different environmental factors (Dawes et al., 1988).

In the present work *F. vesiculosus* from the northern Baltic (Bothnian Sea) and the Atlantic were compared regarding their photosynthesis and tolerance to

UV-B radiation. The plants were cultivated at different seawater salinities to examine possible correlations between salinity and tolerance to UV-B radiation. The low salinity in the Baltic might exert a stressful effect on *F. vesiculosus*. If that is the case, the Baltic *F. vesiculosus* will show a lower tolerance limit to environmental disturbances such as UV-B radiation than the Atlantic *F. vesiculosus*.

Materials and methods

F. vesiculosus was collected at the small island Åstön (62°24′N, 17°45′E) in the Bothnian Sea, northern Baltic Sea (salinity 5 psu) at a depth of 1 m and at the island Hitra (63°39′N; 9°11′E) in the Atlantic Ocean (salinity 35 psu) in the intertidal zone. The algae were placed in aquariums with aeration at 4 °C and a light/dark cycle of 12/12 h with 35 μmol photons $m^{-2}\,s^{-1}$ of PAR (photosynthetic active radiation, 400–700 nm). The Atlantic plants were considerably bigger than the Baltic (1 m compared to 15 cm), the latter with airbladders absent. Algae from these two sites were either cultivated in their own natural seawater or transferred to sea water of the other site, with accordingly less or higher salinity. One week of acclimation to a stepwise changed salinity was used.

Measurement of oxygen evolution was conducted with a Light Pipette (Brammer, Illuminova, Sweden) consisting of a light source, a cuvette for samples (2 ml), an oxygen electrode, a temperature-controlled waterbath, and a control unit with computer. The light source (PAR) was programmed to deliver an increasing irradiance of 20, 100, 200, 300, 400, 500, 600, 700, 800 and 900 μmol photons $m^{-2}\,s^{-1}$, with 2 min at each irradiance. The computer receives data with 2 s intervals from the electrode in the cuvette. Photosynthetic measurements were conducted before and after 5 h exposure to 2.3 W m^{-2} of UV-B (280–320 nm) radiation (Westinghouse SunLamp, FS 20, 20 W). The ultraviolet radiation was filtered through a cellulose acetate film (0.13 mm thickness) to remove shorter-wavelength components(less than 290 nm) not encountered in nature. The temperature was controlled with a water bath during the exposure and the radiance was measured with an IL 1400A broad band Radiometer (International light Inc., Newburyport, MA; USA). A disc of thalli (distal parts taken below the second frond from the tip, approximately 2 years old) with a diameter of 1.5 cm was placed together with filtered seawater in the chamber and kept in darkness for 10 min before measurement. The experiments were carried out at 4 °C. After measurement the alga was placed between two soft papers and the fresh weight (FW) was noted. The maximal photosynthesis (P_{max}) was obtained from the photosynthesis versus irradiance curves at 500 μmol photons $m^{-2}\,s^{-1}$. The dark respiration was calculated as a mean value during the last 5 min of the initial dark adaptation. Five replicates from different thallus were used, and mean values with 95% confidence limits are presented. Statistical analysis was performed with Minitab ANOVA. Tukey's family error rate was used as a post-hoc test. Only significant results are reported in the text.

Pigment analyses were performed with HPLC technique (Wright et al., 1991) by the Water Quality Institute (VKI) in Denmark. Presented pigments are chlorophyll a (Chl a), chlorophyll c (Chl c), fucoxanthin, beta-carotene and the total content of violaxanthin, diadinoxanthin and zeaxanthin.

Results

Photosynthesis

F. vesiculosus in the Atlantic possesses a significantly higher P_{max} than *F. vesiculosus* in the Baltic; 10.3 nmol $O_2\,g^{-1}$ FW s^{-1} compared to 4.0 nmol $O_2\,g^{-1}$ FW s^{-1} (Figure 1). The transfer of plants from Baltic to Atlantic water significantly increased the P_{max} to 8.3 nmol $O_2\,g^{-1}$ FW s^{-1}, an increase with 100% (Figure 1). This increase occurred within 1 week time. The transfer of Atlantic *F. vesiculosus* to Baltic water instead decreased the photosynthesis, which after 7 weeks was as low as 3.5 nmol $O_2\,g^{-1}$ FW s^{-1} (Figure 1). The Atlantic plants died after 8 weeks in Baltic water.

The exposure to UV-B radiation decreased the P_{max} of Atlantic *F. vesiculosus* to 7.0 nmol $O_2\,g^{-1}$ FW s^{-1} (a decrease with 30%) and to 2.2 nmol $O_2\,g^{-1}$ FW s^{-1} (a decrease with 45%) for the Baltic *F. vesiculosus* (Figure 1). The Atlantic plants showed a full recovery of P_{max} after 48 h in low light, while this could not be found for the Baltic plants (Figure 1).

The initial slopes were found to be the same for Atlantic and Baltic *F. vesiculosus* (Figure 2). The negative effects of UV-B radiation on the initial slope were greater for Baltic plants. The Atlantic plants recovered completely after a 48 h recovery in low light, but this was not the case for the Baltic plants (Figure 2). When *F. vesiculosus* from the northern Baltic was transferred to Atlantic water, not only the P_{max} increased, even the tolerance to UV-B radiation. This higher tolerance